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Priming involuntary autobiographical memories in the lab

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ABSTRACT

Involuntary autobiographical memories (IAMs) are recollections of personal past that frequently and spontaneously occur in daily life. Initial studies by Mace (2005) showed that deliberately reminiscing about a certain lifetime period (e.g., high school) significantly increased the number of different IAMs from the same period in subsequent days, suggesting that priming may play a significant role in the retrieval of IAMs in everyday life. In the present study, we used a modified experimental paradigm, originally used by Schlagman and Kvavilashvili (2008), to study IAMs under well-controlled laboratory conditions. Participants completed a monotonous vigilance task twice and reported the occurrence of any spontaneous thoughts that were later classed as IAMs or other thoughts. Priming was manipulated by having experimental participants reminiscing about high school period between the two vigilance tasks and control participants playing simple games. Results showed that participants in the experimental group reported IAMs relating to high school period more frequently during the second vigilance task than those in the control group. In the experimental group, the number of high school memories was marginally higher in the second vigilance task compared to the first vigilance task with the medium effect size, but this within subjects effect was not significant in the control group. Finally, priming also enhanced the retrieval of more remote IAMs in the experimental group compared to the control group. These results suggest that priming may play a significant role in the activation and recall of IAMs and open up interesting avenues for future research.

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The ability to remember our personal past is called autobiographical memory (for more contemporary review see Berntsen & Rubin, 2012; for clinical perspective see also, Watson & Bernsten, 2015). We use it every time when we want to recall something that we personally did or experienced in the past. For example, we may try to recall our last day in a high school. These memories are also called voluntary autobiographical memories. They result from the intention to recall something and typically involve an effortful search (Barzykowski & Staugaard, 2016; Botzung, Denkova, Ciuciu, Scheiber, & Manning, 2008). On the other hand, involuntary autobiographical memories (IAMs) are recollections of personal past that simply come to our mind without any conscious intention at retrieval (Berntsen, 2010; Mace, 2007). Recent studies suggest that this type of involuntary remembering may be even more frequently experienced in daily life compared to voluntary and effortful retrieval (e.g., Rasmussen & Berntsen, 2011; Uzer, Lee, & Brown, 2012).

Since the involuntary retrieval is most likely to happen when an individual is engaged in an automatic activity with low attention demands (Berntsen, 1996), they appear to be retrieved effortlessly in a non-strategic way (e.g., Uzer et al., 2012). For instance, we may experience IAMs while driving home or washing dishes. While IAMs are presumed to be retrieved automatically, little is known about their underlying mechanisms (e.g., basic priming dependency or cognitive load dependency). More specifically, we may ask "how" IAMs come to mind and "why" they are related to this particular event from our personal past. While answering the "how" question, researchers are mainly interested in variables that may modify the frequency of IAMs retrieval. For example, while addressing the question about the effects of cognitive load on IAMs, Vannucci, Pelagatti, Hanczakowski, Mazzoni, and Paccani (2015) showed that the occurrence of IAMs was substantially limited by the high level of cognitive demand of the ongoing mental activity. At the same time, the "why" question addresses mainly effects of priming on IAMs (e.g., Mace, 2005). For instance, we may ask, why a few days after running into a long-unseen friend from high school we are suddenly flooded by memories related to high-school period. This also raises the question of whether IAMs are "simply randomly triggered through the random experience of cues" (p. 875; Mace, 2005), or are organised by some cognitive processes. Although there is a growing body of research investigating priming effects on IAMs (e.g., Ball & Hennessey, 2009; Mace

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& Clevinger, 2013; Mace, Clevinger, & Bernas, 2013), to the best of the authors' knowledge, there is only one study that addressed directly the effects of priming on IAMs (Mace, 2005).

It is worth highlighting that the questions concerning cognitive mechanisms of IAMs may be considered as one of the most important issues in relation to understanding IAMs (Berntsen, 2009, p. 86), especially given that involuntary memory processes may play an important role in emotion regulation (e.g., Gross, 2001) and mental disorders, such as dysphoric mood (e.g., Kvavilashvili & Schlagman, 2011), posttraumatic stress disorder (Berntsen, 2015) or depression (Moulds & Krans, 2015). Therefore, developing our knowledge about IAMs may contribute to gaining an insight into human cognition in everyday life, and even more importantly, in clinical disorders. For example, as pointed out by Berntsen (2015), mechanisms that govern the retrieval of everyday IAMs may be especially helpful in explaining the phenomenon of recurrent intrusive remembering of traumatic events.

Effects of priming on IAMs

According to the self-memory system model proposed by Conway and Pleydell-Pearce (2000), autobiographical memory consists of a hierarchical network of interconnected nodes. Very specific and concrete information with sensory details (e.g., *swimming in the Atlantic Ocean for the first time*) are stored at the bottom of the network. They are further connected to super-ordinate levels of general events (e.g., *swimming in the oceans*), common themes (*swimming*, *doing sports*), or even, at the highest level of memory nodes, important periods in one's life (e.g., *when I was young*). The nodes can be linked to each other in various ways. For example, by activating more general levels (*working in Portugal for one year*), we may gain access to a specific memory of a particular event (*swimming in the Ocean the day I visited Porto*). This activation may spread across the network horizontally and vertically (i.e., upwards) and, most importantly, it is basically launched by different types of cues (i.e., internal or external) that play a crucial role in the retrieval of an autobiographical memory content. Therefore, examining the relationship between particular cues and memories may be helpful in answering the question of why a certain memory has just come to one's mind.

It can be argued that the issue of "why" IAMs relate to some particular event pertains to a broader question. Namely, given that IAMs occur automatically in response to incidental external and internal cues, why are we not flooded by the same memories in response to the same cues? One might expect to always retrieve the same involuntary memory in response to a distinct cue, for example, a red pen. This might be especially true if there is only one event that maps perfectly onto such distinct trigger. However, it is more likely that cues usually do not exclusively match only to one memory. According to the principle of cue overload, it is most likely that a cue will match several past events (Berntsen, 2009). Elaborating it further, Berntsen (2009) suggests that the more events are associated with a particular cue, the less efficient this cue will be in triggering any of them. Discussing this phenomenon, Berntsen (2009) introduced the so-called cue-item discriminability, which can be defined as "how easily a given cue isolates an item" (Rubin, 1995, p. 151 as cited in Berntsen, 2009, p. 107). Berntsen, Staugaard, and Sørensen (2013) carefully examined the relationship between cue and memory in their pioneering work in which, for the first time, they were able to predict the occurrence of an involuntary episodic memory based on the manipulation at encoding. Across four experiments they found that involuntary episodic memories were retrieved more often in response to unique compared to repeated (i.e., associated with many memories) cues, which accords well with the principle of the cue-overload. The more unique the association between the cue and a given memory was, the more likely the triggering of the memory was. However, it can be argued that the cues that are very unique and distinctively related to a given memory target are rather rare in daily life and most cues map onto many different memories and events. Yet, such cues still seem to easily trigger IAMs. Therefore, it is reasonable to ask what processes may increase cue-item discriminability that allows for efficient activation of a particular involuntary memory. Put differently, what kind of process makes an ordinary cue capable of bringing a certain IAM to mind?

Addressing this question, Mace (2005) proposed priming as one possible cognitive process that could contribute to the formation of IAMs (for a review of priming processes, see also Anderson & Bower, 1974; Roediger & McDermott, 1993). For example, thinking about the long-unseen friend from high-school can prime a number of autobiographical memories that refer to each other either thematically (e.g., previous joint activities) or temporally (different events from the same lifetime period). Importantly, priming mechanism perfectly addresses the cue overload principle. More specifically, the activation of a particular part of autobiographical knowledge base (Conway & Pleydell-Pearce, 2000), for example, a high school lifetime period, narrows the pool of possible memories that can be potentially elicited in response to a certain cue. Thus, priming may increase the cue-item discriminability and, for some memories, boost the likelihood that memory will enter a person's awareness. In the example described, it will be more likely that memories relating to the high school period would be elicited when a relevant cue appears. In addition, priming may activate not only memories relating to the high school period (e.g., being between 16 and 19 years old), but also memories relating to more distant past (e.g., going to the primary school). The retrieval of the past may per se facilitate the retrieval of many different nodes and levels associated with the activated part of autobiographical knowledge base. In other

words, retrieving a certain memory from the past may cause spreading activation across the nodes in the network that are closely associated with retrieved memory either temporally or thematically. As a result, someone who has been reminiscing about the past should be more prone to involuntarily retrieve memories from more distant rather than recent past.

Mace (2005) considered voluntary remembering to be the most likely way of priming IAMs and proposed two effects that voluntary remembering may have on IAMs. First, remembering the past voluntarily may cause spreading activation to occur throughout the network of memories. As a result, some involuntary high school memories may simply pop in our mind just after or even during the voluntary remembering. Some of them may also occur any time later. For instance, memories about the high school crush may start entering a person's awareness a few hours or even days after running into a long-unseen friend. Second, some memories may not enter awareness because they were too weakly activated. However, it is likely that these weakly activated memories may be later favoured by the involuntary memory retrieval especially because their activation level would be higher compared to memories that were not activated at all. To put it differently, there is a greater chance of eliciting a weakly activated memory compared to non-activated ones. Thus, the priming effect should directly or indirectly narrow the field of memories that could be potentially elicited.

A series of studies published by Mace (2005) addressed the role of priming in the retrieval of IAMs. For example, in Study 1, after recording IAMs in a structured diary for 14 days, participants were inquired about being preoccupied with any thoughts (e.g., themes such as problems at work) during the preceding period of time. The findings showed a high correlation between the life-theme thoughts and IAMs relating to those mental contents. For instance, someone preoccupied with thoughts about his/her partner, was more likely to report IAMs relating to such theme. However, since causal inferences could not be drawn, Mace (2005) conducted two more studies with an experimental manipulation. In Study 2, participants also recorded IAMs in a structured diary, but they were primed during that period in the laboratory with voluntary reminiscing session (recalling episodes from high school for 30-minutes). Mace observed higher frequency of high-school IAMs after voluntary recall of memories pertaining to high school. Study 3 replicated and extended the priming effects of Study 2 using two different and more generic lifetime periods, namely, participants recalled events from the previous year or from when they were aged 13–16. In line with the results of Study 2, participants experienced more memories relating either to the past year or ages between 13 and 16, depending on the manipulation used.

The findings lend strong support to the idea that priming plays an important part in the occurrence of IAMs. By engaging participants in voluntary reminiscing, Mace provided the first evidence that IAMs depend, to some extent, on priming, and their frequency can be modified by voluntary retrieval. In addition, since IAMs were not direct repetitions of memories recorded in the laboratory, it implies an associative type of IAM priming. Put differently, an individual may more often experience an IAM relating temporally or thematically to previously recalled lifetime period rather than an exact repetition of memory content retrieved in the laboratory (Study 2 and Study 3).

The present study

Mace's (2005) study clearly demonstrated that the occurrence of IAMs may rely on priming mechanism. However, it is important to highlight that since these studies were conducted using a naturalistic diary method, there is still a need for further research so that Mace's initial findings can be replicated with more experimentally oriented approach. Therefore, the overriding goal of the present study was to empirically verify the role of priming in involuntary retrieval in the lab. More precisely, we wanted to investigate the effect of voluntary reminiscing about the past on the content and temporal orientation of IAMs. To fulfil this goal, we modified an often-used experimental procedure, developed by Schlagman and Kvavilashvili (2008), that allows studying IAMs under well-controlled conditions (e.g., Barzykowski & Niedźwieńska, 2016; Barzykowski & Staugaard, 2016; Plimpton, Patel, & Kvavilashvili, 2015; Vannucci et al., 2015). In Schlagman and Kvavilashvili's original procedure, participants are instructed to perform a monotonous vigilance task that consists of infrequent target slides ($n = 15$) with vertical lines in a stream of 785 slides with patterns of horizontal lines. In addition, on each trial, short verbal phrases are presented in the centre of the screen, some of which may trigger IAMs. Participants have to interrupt the vigilance task every time they experience such a memory.

We used several modifications, which are explained in detail in the methods section below. However, the most important differences between our modified procedure and the original method by Schlagman and Kvavilashvili (2008) involved (1) engaging participants in two phases of the vigilance task with the same set of 400 cues (phase 1 and phase 2),[1] (2) instructing them to record any spontaneously occurring thoughts during the task, and 3) at the completion of phase 2, asking participants to indicate which of the recorded thoughts were memories (for similar instructions, see Barzykowski et al., 2016; Barzykowski & Staugaard, 2016). With regard to the first modification, we decided to use two IAM collecting phases to examine the direct effect of voluntary reminiscing about the past on IAM retrieval.

Second, we carefully controlled the risk of participants entering into the retrieval mode during the vigilance task (Tulving, 1983), in which "the cognitive system is prepared for or expects memory construction and recollection"

(Conway, 2001, p. 1379). As we wanted to minimise intentionality during retrieval (Barzykowski et al., 2016; Vannucci, Batool, Pelagatti, Mazzoni, & Dekel, 2014) and to maximise involuntary retrieval (Barzykowski & Staugaard, 2016), participants were instructed to report any spontaneously occurring thoughts. This procedure allowed us to minimise the chances that IAMs collected during the vigilance tasks were produced by intentional recall (Barzykowski et al., 2016). In addition, due to the fact that participants were not exclusively focused on writing down only IAMs, it is rather unlikely that they were more willing to retrieve IAMs related to the lifetime period that was a theme of voluntary retrieval.

In general, the procedure consisted of three parts: (1) the first IAM collecting phase (before the manipulation), (2) experimental manipulation that involved the voluntary reminiscence session (only in the high school group) and a filler task (in both the high school group and the control group), (3) the second IAM collecting phase (after the experimental manipulation). Participants from the experimental (the high school) group were primed with the voluntary reminiscence session that involved recalling episodes from high school for 15 min[2] between the first and the second IAM collecting phase. By using this design, we were able to manipulate the priming between- and within-subjects. It is worth to underline that in order to investigate the temporal orientation of primed memories, we used one lifetime period for priming: high school. When, after the priming session, one is looking only for memories that are exclusively related to a certain type of school (e.g., "I suddenly remembered the time in my high school French class when", Mace, 2005, p. 879), this limits the examination of the priming effect only to specific memories thematically related to the school. We believe that the effect of priming may be more general, that is, priming may generally increase the frequency of experiencing memories from the primed period of the personal past. We thus expected that priming would boost not only retrieval of memories thematically related to the school that was a theme of the voluntary memory recording session (e.g., *the time in my English class when I accidently forced the door*), but, in general, also memories from this lifetime period (e.g., *I suddenly remembered going to the Baltic Sea Cost when I attended high school*). For that reason, in our study, participants were asked to identify the temporal context of each collected involuntary memory, no matter whether they were or were not thematically related to the high school. We expected to observe higher frequency of memories from the period of time that was retrieved during the voluntary memory recording phase. To put it differently, participants should be immersed more into their past after deliberately reminiscing about it compared to participants who did not previously record their past at all.[3]

Finally, we wanted to examine the priming effect in the laboratory while overcoming some limitations of a diary method that is mainly the lack of systematic control over a wide variety of independent (e.g., type of cues, the ongoing activity during the memory retrieval) and dependent variables (e.g., retrieval times of IAMs). Importantly, in experimental settings, compared to diary methods, all participants are studied under exactly the same conditions. For example, by providing participants with standardised sets of cues with precise control over their number, emotional valence and presentation time, we were able to analyse more directly the relationship between the priming effects, triggers and IAMs. However, probably the biggest advantage of the experimental design is that it allows to directly examine the retrieval of IAMs. Therefore, by fully controlling the presentation of triggers and the time at which IAMs are reported, we are able to measure and analyse the retrieval times (RT) for the subset of IAMs triggered by the verbal cues. Taking all these together, we argue therefore that employing the experimental design in the present study can allow to further improve our knowledge about priming effects compared to the procedure used by Mace (2005).

In line with Mace (2005), in the present study, the dependent variable was the proportion of IAMs related to a certain period of time (e.g., high school) out of a total number of memories reported by a participant. Such an *involuntary memory density index* (henceforth called also an IMD index) was calculated for each lifetime period: before kindergarten, kindergarten, primary school, middle school, high school, college, time after college. In addition, we calculated remote past IMD index that is the proportion of all memories that come from lifetime periods before the college time (before kindergarten, kindergarten, primary school, middle school, high school) out of a total number of all memories reported by a given participant. Since we conducted the present study only with undergraduate students, all periods before the college time relate to the participant's relatively remote past compared to the college time. It allowed us to examine the tendency to involuntarily retrieve remote past. The higher the IMD index, the higher the proportion of memories with certain characteristics in the total number of all reported memories.

Hypotheses

In general, we expected that voluntary reminiscing about the high school period in the experimental condition should enhance the retrieval of IAMs from this lifetime period. More precisely, in the second IAM collecting phase (i.e., after voluntary reminiscence session) we should observe higher IMD index relating to the period of high school in the high school group compared to the control condition (between subjects differences). Importantly, for the high school group, this index should also be higher in the second phase compared to the first one (within-subject differences). In addition, given that IAMs typically refer to recent period of time (e.g., Berntsen, 1996; Berntsen & Hall, 2004; Vannucci et al., 2014) and assuming that voluntarily reminiscing about the past truly activates IAMs from more distant past, the within-

subject effect (i.e., difference between the first and the second phase in the high school group) and between-subject effect (difference between groups in the second phase), described above, should also be observed for the remote past IMD index and the age of recorded memories.

Method

The Research Ethics Committee approved the usage of the experimental method adapted from Schlagman and Kvavilashvili (2008). Written consent for participation was obtained prior to data collection.

Design

The mixed subject design was employed in the present study. We manipulated lifetime period that was retrieved just before the second involuntary memory collecting phase (between-subject factor: high school group vs. control group) and measured IMD indexes twice (within-subject factor: first vs. second involuntary memory collecting phase). We used one lifetime period that was voluntarily retrieved by participants, that is, high school. It allowed us to compare the high school condition with a control group where participants were not engaged in the voluntary retrieval at all.

Participants

A total of 60 participants (39 females, $M_{age} = 22.14$, SD = 2.27, range 19–31 years, all but six participant were undergraduate students) were recruited and randomly assigned to the two experimental conditions: the control group and the high school group. They were all screened for depression using the Polish version of the Beck Depression Inventory (BDI) (Parnowski & Jermajczyk, 1977). Since various mental disorders may affect retrieval of IAMs (e.g., depression, Moulds & Krans, 2015; Watson, Berntsen, Kuyken, & Watkins, 2013), we excluded from the sample four participants who scored 20 or above. Therefore, the final sample consisted of 27 participants in the control condition (17 females, $M_{age} = 22.37$, SD = 2.31, range 19–27 years) and 29 participants in the high school condition (18 females, $M_{age} = 22.20$, SD = 2.36, range 20–31 years). Students participated in return for a gift card worth around 20 PLN (c.a. 5$ USD).

Materials

In the present study, we used the Involuntary Memory Program (IMP) that consisted of two IAM collecting phases separated by the voluntary memory recording phase. In addition, participants from both groups performed the filler task just before the second IAM collecting phase.

Involuntary memory program

We employed the IMP that is described elsewhere in more detail (e.g., Barzykowski et al., 2016, pp. 5–6; also, Barzykowski & Staugaard, 2016, p. 524). This fully computerised experimental procedure was adapted from the method originally developed by Schlagman and Kvavilashvili (2008). The main differences between the present task and Schlagman and Kvavilashvili's (2008) original design were as follows: (1) use of a computerised version for all questions, (2) providing participants with 400 slides twice, (3) randomly ordering the trials and cues for each participant, (4) extending the presentation of each trial from 1.5 to 2 s, and (5) instructing participants to write down any involuntarily occurring thoughts.

The vigilance task involved detecting patterns of vertical lines (8 target slides) in a stream of 392 non-target slides with horizontal lines. Each slide was presented for 2 s during each separate trial. In addition, short verbal phrases (e.g., *riding a horse*, *listening to the concert*) were displayed on each slide in the centre of the screen. There were an approximately equal number of neutral (N = 134), positive (N = 133), and negative (N = 133) phrases,[4] that constituted the final pool of 400 phrases randomly selected for each participant from the pool of 800 phrases used in previous studies (e.g., Barzykowski et al., 2016; Barzykowski & Staugaard, 2016). Participants first completed two practice sessions that consisted of 25 trials each (there was only one pattern of vertical lines presented) and which displayed verbal phrases in the same fixed order for each participant. Following these practice trials, the main vigilance task began that consisted of 400 slides and phrases randomly generated for each participant. The second IAM collecting phase was the same (including the order of the cues) as the first phase.[5]

Voluntary memory recording phase

High school condition. The voluntary remembering phase was built into the IMP (for more details see below) and was launched between the first and second IAM collecting phase. It took around 12–15 min and consisted of open-ended and close-ended questions. They were aimed at activating as broadly as possible the part of autobiographical memory knowledge base that relates to the high school lifetime period (between 16 and 19 years old). These questions concerned: (1) A name of the school that the participant attended, (2) the range of age while being in the school (1 = *13–16*, 2 = *16–19*), (3) the educator's name and (4) her or his subject, (5) the extent to which the participant liked attending the subject (1 = *I didn't like it at all*, 2 = *I didn't like it*, 3 = *I don't think I liked it*, 4 = *It was neutral to me*, 5 = *I liked it somewhat*, 6 = *I liked it*, 7 = *I liked it a lot*), (6) the extent to which this subject was interesting (1 = *It wasn't interesting at all*, 2 = *It wasn't interesting*, 3 = *I don't think it was interesting*, 4 = *It was neutral to me*, 5 = *It was somewhat interesting*, 6 = *It was interesting*, 7 = *It was very interesting*), (7) the name of the favourite teacher and (8)

his or her subject, (9) the extent to which the participant liked attending this subject (1 = *I didn't like it at all*, 2 = *I didn't like it*, 3 = *I don't think I liked it*, 4 = *It was neutral to me*, 5 = *I liked it somewhat*, 6 = *I liked it*, 7 = *I liked it a lot*). Participants were then instructed to recall and name any four events from the high school period (10). They were also asked to choose one of those events and describe it more thoroughly (11). In addition (12), they indicated their grade (1 = *grade 1*; 2 = *grade 2*, 3 = *grade 3*), (13) their age (1 = *13 years old*, 2 = *14 years old*, 3 = *15 years old*, 4 = *16 years old*, 5 = *17 years old*, 6 = *18 years old*, 7 = *19 years old*), (14) the intensity of emotions experienced during the event (1 = *not intense at all*, 2 = *not intense*, 3 = *rather not intense*, 4 = *slightly intense*, 5 = *somewhat intense*, 6 = *intense*, and 7 = very *intense*), (15) the emotional valence of the original event (1 = *very unpleasant,* 2 = *rather unpleasant*, 3 = *unpleasant*, 4 = *neutral*, 5 = *rather pleasant*, 6 = *pleasant*, 7 = *very pleasant*), (16) the time of year (1 = *spring*, 2 = *summer*, 3 = *autumn*, 4 = *winter*), (17) the time of week (1 = *Working day, from Monday to Friday,* 2 = *Weekend or non-working day*) and (18) the time of day when the event occurred (1 = *Before noon, between 6 am and 12*, 2 = *In the afternoon, between 12 and 6 pm*, 3 = *In the evening, between 6 pm and 12 am*, 4 = At *night, between 12 am and 6 am*). Next, they were instructed to recall and name any four of the most pleasant events from the high school period (19). They chose one of them and answered analogous questions as described above (11–18). This procedure was repeated for recalling and naming three most important events from the high school period (20) and two most important achievements from the high school period (21). In total, participants answered 43 questions and recalled 13 specific events.

Filler tasks

After finishing the voluntary memory recording phase (experimental condition) and before starting the second IAM collecting phase (both conditions) participants played a few games selected from CONCENTRATION Part 2. Mind Academy software for 10 min (experimental condition) or 20 min (control condition). These exercises engage: ability to analyse stimuli and information, constructive problems solving, inductive and deductive reasoning. They were set on a low level of difficulty without time pressure. The material in the games was rather abstract and non-verbal. Therefore, it is rather unlikely that it might have involuntarily or voluntarily triggered any episodic or autobiographical memories from the personal past.

Procedure

Participants were tested in groups of two to six. Just before starting the first and second IAM collecting phase, they filled in the Positive and Negative Affect Schedule (PANAS; Brzozowski, 2010).[6] Participants were informed that they were free to withdraw from the study at any point. In addition, the experimenter assured them that their responses would be anonymous, and informed them that they could refrain from reporting particularly sensitive thoughts by typing "X" as an answer, or (if possible) by providing a general description of their thoughts rather than a detailed account. At the beginning of the session, the experimenter only briefly introduced the participants to the procedure. They were informed that experimental session would consist of three main parts. They were told that the first part would examine how people concentrate on monotonous and boring tasks. The task was then described in more detail. It was explained that since the study would examine how people concentrate on monotonous vigilance task, the task would need to be quite long and onerous. Participants were also told that the condition they would be taking part in would have a short break between the first and the second vigilance task and that participants assigned to the other group would also need to do the vigilance task twice but without taking a break.

High school condition. Participants were then informed that the break would last about 20 min and examined how people remember the time when they were in high school. They were assured that they would answer a series of questions concerning their personal past and experiences that related only to this period of time. In addition, the filler task was also described as a part of another study in which various games would be used. Participants were told that in order to find the best game for further studies, they would play each of the four games. They responded to additional questions by rating on 7-point scales the extent to which they found these games difficult, funny, interesting. After finishing the filler task, participants started the second IAM collecting phase.

Control condition. The only difference between the high school condition and the control condition was that participants were not engaged in the voluntary memories recording phase. They played games for 20 min (i.e., filler task) before they started the second IAM collecting phase.

Involuntary memory collecting phase

As in the previous studies (e.g., Barzykowski et al., 2016; Barzykowski & Staugaard, 2016; Vannucci et al., 2014, 2015), participants were instructed to identify a vertical pattern of lines by pressing a red button ("m" on the keyboard). In addition, they were informed that they would also see word phrases in the centre of the screen. It was explained that these word phrases were used in another condition and they should not respond to them during the current study. Next, participants were engaged in the first practice session that required responding only to vertical lines. They were then informed that during the computer task they might experience different kinds of thoughts, and they were provided with examples of such thoughts, including personal goals, words, current concerns, plans, and memories. However, no particular emphasis was put on memories during the briefing. Participants

were only told that memories could be diverse (i.e., specific, general) and pertain either to recent or remote past events. The participants were asked to report any spontaneous thoughts by pressing the spacebar as soon as they became aware of them. Next, they performed the vigilance task and if they experienced any involuntary thought, they recorded them.[7]

After completing the second practice session, participants started the main vigilance task. Each time they pressed the spacebar, they were asked to provide a brief description of the content of their thoughts (by typing it into the computer program). They also specified what triggered the content (1 = *Something in the program*, 2 = *Something in my mind*, 3 = *Something in the surroundings*, 4 = *Nothing*) and provided a brief description of the trigger. In addition, due to the fact that participants performed the IAM collecting phase twice, during the second phase they also indicated whether the content was being recorded the first (or more) time. It allowed us to control the extent to which participants had been recording one memory more than once. After answering these two (phase 1) or three (phase 2) questions, participants clicked "continue" to return to the vigilance task. On completion of the first IAM collecting phase, the program was automatically stopped, and started the break that was described above. After the break experimenter launched the second IAM collecting phase.

At the completion of the vigilance task, participants answered open-ended questions concerning what they thought: (1) the true goal of the study was, (2) the true goal of performing the computer program was, (3) the study was about, (4) good performance during the study was. In addition, they were asked what they did during the study to perform well (5). They were then provided with written and verbal instructions describing the nature of autobiographical memory (as, for example, in Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009, p. 410) and were informed about the second part of the study. During this part, participants reviewed all of their thoughts recorded in the IAM collecting phases, one at a time and in the same order as they had been recorded. Participants were instructed to decide whether each thought was an autobiographical memory or not by clicking the "start" button (if it was) or the "next" button (if it was not). After clicking the "start" button, they were asked to describe the memory more thoroughly by typing it into the computer program and rated (on 7-point scale) the lifetime period from to which the memory belongs (1 = *before being in a kindergarten*, 2 = *while being in the kindergarten*, 3 = *while being in the primary school*, 4 = *while being in the middle school*, 5 = *while being in the high school*, 6 = *while being in the college*, 7 = *period after college*). Wherever it was possible (i.e., for specific or general memories of events that an individual experienced at a certain age), they also estimated the age of the memory by indicating their age when the event occurred. They also specified whether the memory was general or specific by classifying an event as: (1) extended in time (e.g., last week), (2) repeated in the past (e.g., regular meetings), or (3) referring to a particular situation happening within 1 day (e.g., the day I met X). Both 1 and 2 were then classified as general events, while 3 was classified as specific events. At the completion of the IMP, they filled in the BDI (Parnowski & Jermajczyk, 1977).

Results

For all statistical tests, reported below, the rejection level was set at .05. None of the participants reported having guessed the real purpose of the study.

Equivalence of study groups

To test the comparability of groups, the overall means for the BDI were entered into independent *t*-test. The results presented in Table 1 show that we did not observed any significant differences between the groups, $t(54) = .17$, $p = .86$, $d = .05$. Also, the overall means for the mood scores as measured by PANAS were entered into two separate 2 (group: control, high school) × 2 (collecting phase: first phase, second phase) mixed ANOVAs with repeated measures on the last factor. The analysis revealed a significant main effect of collecting phase on the positive, $F(1, 54) = 16.88$, $p < .001$, $\eta^2 = .24$, and negative affect, $F(1, 54) = 10.88$, $p < .002$, $\eta^2 = .17$. More specifically, during the second phase participants had lower ratings on positive and negative affect scales compared to the first phase (see Table 2). It is possible that performing a monotonous vigilance task for the first time and additional cognitive activities followed by the second IAM collecting phase somehow settled participants down. Since they became familiarised with the procedure, they might have felt less nervous and stressed as well as less active and lively, especially because the tasks were not too exciting and challenging. However, neither the main effect of group, nor the group by phase interaction were significant. Finally, to control for the possible differences in the timeline of the experiment, the overall means for the length of the whole program duration (phase 1 plus the break plus the voluntary memory recording phase in the high school group[8] plus phase 2) were entered into independent *t*-test. The groups (high school: $M = 47.25$ min., SD = 15.81; control: $M = 53.70$ min., SD = 16.93) did not differ

Table 1. Means and standard deviations for variables measuring mood across groups.

	Group			
	High school		Control	
	M	SD	*M*	SD
Beck depression inventory	8.31	6.19	8.04	5.69
PANAS: Positive affect_1	46.21	7.96	48.26	8.24
PANAS: Positive affect_2	41.45	11.51	42.11	13.08
PANAS: Negative affect_1	21.34	8.13	18.41	3.46
PANAS: Negative affect_2	17.28	4.08	17.19	3.13

Table 2. Means and standard deviations for variables measuring number of thoughts, memories and IMD index.

	Group			
	High school		Control	
	M	SD	*M*	SD
Number of thoughts_1	17.90	19.23	20.70	18.20
Number of thoughts_2	15.38	12.47	19.11	15.49
Number of memories_1	3.31	3.36	3.31	3.45
Number of memories_2	1.38	1.15	1.38	1.06
Retrieval time_1	2.43	1.05	2.52	0.91
Retrieval time_2	3.43	2.29	3.27	1.52
Specificity_1	.66	.35	.62	.33
Specificity_2	.43	.44	.75	.35
Before kindergarten	–	–	–	–
Kindergarten	–	–	–	–
Primary school IMD index_1	.10	.17	.08	.24
Primary school IMD index_2	.12	.23	.09	.26
Middle school IMD index_1	.02	.04	.07	.24
Middle school IMD index_2	.07	.24	.02	.08
High school IMD index_1	.14	.25	.15	.30
High school IMD index_2	$.31^{1}$	.40	$.02^{1}$	.08
College IMD index_1	.66	.33	.63	.41
College IMD index_2	.46	.40	.74	.44
After college IMD index_1	.06	.24	.05	.15
After college IMD index_2	.06	.24	.14	.31
Remote past IMD index_1	$.11^{a}$	.24	.21	.38
Remote past IMD index_2	$.51^{a,1}$	.42	$.13^{1}$	.27
The age of the memory_1	19.22	2.93	20.46	3.32
The age of the memory_2	18.69	2.47	21.20	2.08

Notes: While means with the same numerical subscripts (e.g., ^{1,2}) are significantly different between columns, means with the same literal subscripts (e.g., ^{a,b}) are significantly different between rows. Please note that each index is the proportion of memories from a certain period in all IAMs reported by the individual.

significantly from each other in this regard, $t(53) = 1.46$, $p = .15$, $d = .39$.

Strategy for data analysis

Only the entries that were classified by participants as autobiographical memories were included in the analyses reported below. In addition, all these entries were screened by the independent judges as memories or non-memories. All entries identified by participants as memories were classified in the same way by judges. Examples of entries identified by participants as non-memories were semantic memories unrelated to the personal past (*Smolensk plane crash in 2011*), semantic thoughts (lyrics, rhymes), future plans (*going to the cinema with friends this Friday*), thoughts relating to the current situation (*what a boring task, I am hungry*). For all IAMs reported by participants as triggered by a verbal phrase, we calculated RT, which was the time between the moment when the individual indicated a memory, and the onset of the verbal phrase which s/he had indicated as the trigger of that memory. As in the previous studies on IAMs (Barzykowski & Staugaard, 2016; Berntsen & Hall, 2004; Schlagman & Kvavilashvili, 2008), since participants provided dependent multiple observations, we calculated mean RTs, IMD indexes, specificity ratios and the age of memories for each participant. We excluded outliers with a value of 2.5 SD or more above or below the mean of the group.

Number of thoughts and IAMs

The mean number of involuntary thoughts and IAMs (see also Table 2) were separately entered into a 2 (group: control, high school) by 2 (collecting phase: first phase, second phase) mixed ANOVAs with repeated measures on the last factor. There were no significant main effects of group, recording phase, or the group by phase interaction for the number of thoughts. However, the ANOVA on the number of IAMs revealed a significant main effect of recording phase ($F(1, 53) = 18.00$, $p < .001$, $\eta^2 = .25$), with participants recording lower number of IAMs in the second phase compared to the first phase. However, neither the main effect of group, nor the group by phase interaction were significant (Fs < 1). To check for repetitive entries, the mean number of memories that had been recorded during the second phase for the first time or more times were entered into independent *t*-test. The groups did not differ in the number of memories that were written down for the first time (control $M = 1.27$, $SD = 1.04$, high school $M = 1.28$, $SD = 1.13$; $t(53) = .02$, $p = .98$, $d = .00$), or more times (control $M = .12$, $SD = .59$, high school $M = .10$, $SD = .31$; $t(53) = .09$, $p = .93$, $d = .00$).[9]

Effects of priming: Recall of IAMs from different lifetime periods

Table 2 shows the mean IMD indexes for each of the life time periods such as primary school, middle school, high school, college and after college. No memories were recalled for early childhood covering periods of kindergarten and before kindergarten. Consequently, means for these periods are absent from the table. The mean IMD index for each lifetime period were entered into a 2 group (control, high school) × 2 collecting phase (phase 1, phase 2) mixed ANOVA with the repeated measure on the last factor.[10] There were no significant main effects, recording phase or the group by phase interaction for the mean IMD indexes for primary school, middle school, college and after college periods.

However, the results revealed a significant main effect of group for the high school IMD index. As predicted (see Table 2), the high school group had a higher IMD index related to the lifetime period of high school compared to the control group ($F(1, 33) = 4.95$, $p = .033$, $\eta^2 = .13$). The main effect of recording phase was not significant ($F < 1$). In addition, we observed a significant group by phase interaction, $F(1, 33) = 4.62$, $p = .039$, $\eta^2 = .12$. While there was no effect of condition in phase 1 ($p = .84$), the experimental group significantly differed from the control group in phase 2. More specifically, post hoc tests indicated that the frequency of memories related to the high school lifetime period recorded in the second phase was significantly higher in the high school group than in the control group ($p = .003$, $\eta^2 = .22$). At the same time, the difference between the first and second phase in the high school group was approaching statistical significance ($p = .087$, $\eta^2 = .11$) with

medium effect size, but there was no difference between these two phases in the control group ($p = .21$).

Effects of priming: recall of remote IAMs

While the main effect of group on the remote past IMD index was not significant ($p = .10$), we observed significant effect of collecting phase ($F(1, 33) = 4.14$, $p = .050$, $\eta^2 = .11$) with memories from the remote past being reported more often during the second phase compared to the first phase. However, this main effect was qualified by the significant group by phase interaction ($F(1, 33) = 9.76$, $p = .004$, $\eta^2 = .23$). Post hoc tests revealed that participants in the high school group experienced memories from remote past more often in phase 2 compared to phase 1 ($p = .001$, $\eta^2 = .39$), but there were no differences between these two phases in the control group ($p = .45$). In addition, while there was no effect of condition in phase 1 ($p = .38$), in phase 2 the remote past IMD index was higher in the high school group compared to the control group ($p = .001$, $\eta^2 = .29$).

The age of recorded memories

In addition to assigning their past memories to certain life time periods, participants also indicated how old they were when the event in memory took place. The overall mean ages of recorded IAMs were entered into a 2 (group: control, high school) × 2 (collecting phase: first phase, second phase) mixed ANOVA with repeated measures on the last factor. The main effect of group was significant ($F(1, 30) = 5.47$, $p = .026$, $\eta^2 = .15$). Memories recorded in the control group were rated as significantly more recent ($M = 20.83$, SD = 2.07) compared to the high school group ($M = 18.95$, SD = 2.07). At the same time, the effect of phase and the group by phase interaction were not significant ($p = 26$). Since we hypothesised that memories recorded during second phase should be more remote in high school group compared to the control group, for exploratory purposes we run planned comparisons. As expected, memories recorded during the second phase were older in the high school group compared to the control group ($p = .005$, $\eta^2 = .27$).

Additional findings

Cue analysis

In both groups, the majority of memories had identifiable cues (95% in the control and 97% in the high school condition). Analysis of cue type showed that while 82% of cues in the control group (86% in phase 1 and 74% in phase 2) and 76% of cues in the high school group (78% in phase 1 and 69% in phase 2) were reported as being triggered by word cues on the screen, only 0.75% of memories in the control group and 6% of memories in the high school group were reported as being triggered by stimuli in the surrounding environment. Similarly, the number of memories triggered by internal thoughts was only 11% in the control group (10% in phase 1 and 15% in phase 2) and 15% in the high school group (12.50% in phase 1 and 21% in phase 2). Finally, in both groups very few memories were reported to have no triggers (5% in the control and 3% in the high school groups).

RT of IAMs

The mean RT of IAMs (see Table 2) were entered into a 2 (group: control, high school) × 2 (collecting phase: first phase, second phase) mixed ANOVA with repeated measures on the last factor. There were no significant main effects of group ($p = .95$), recording phase ($p = .07$) or the group by phase interaction ($p = .79$).

The specificity of remembered IAMs

We entered the mean specificity ratio (i.e., the proportion of specific relative to the total amount of memories) into a 2 (group: control, high school) × 2 (collecting phase: first phase, second phase) mixed ANOVA with repeated measures on the last factor. While there were no significant main effects of group ($p = .13$) and recording phase ($p = .55$), the group by phase interaction was significant, $F(1, 32) = 4.28$, $p < .047$, $\eta^2 = .12$. The only significant difference was observed in the second phase between the control and the high school group ($p = .013$, $\eta^2 = .15$). As it can be seen in Table 2, the specificity ratio in the second phase was significantly lower in the high school group compared to the control group. At the same time, the difference in this regard between the first phase and second phase in the high school group was close to statistical significance ($p = .06$, $\eta^2 = .18$).

General discussion

We examined the effect of priming on IAMs using the experimental procedure that allows studying IAMs under well-controlled conditions. We used a design in which participants were or were not engaged in the voluntary remembering before the second IAM collecting phase. This allowed us to manipulate the priming mechanism between-subject (participants who were engaged in voluntary remembering vs. those who were not) and within-subject (differences between the first and the second IAM collecting phase). We examined the IMD index for each lifetime period. For example, the high school IMD index represented the proportion of IAMs from the time of high school (ages 16–19) out of all the memories reported by the participant. We hypothesised that the frequency of IAMs from the period of high school, as measured by the IMD index, would increase after voluntary retrieval of memories from that period. In addition, we expected to observe higher frequency of remote IAMs after voluntary retrieval of remote personal past. Importantly, by using a fully computerised experimental procedure we were able, on one hand, to carefully control the context of IAM occurrence (e.g., triggers, ongoing

cognitive activity). On the other hand, and even more importantly, we were able to more directly analyse the RT of IAMs (as in Schlagman & Kvavilashvili, 2008).

In line with our predictions, we observed the priming effect on IAMs with participants who were reminiscing about the high school period for 15 min reporting significantly higher number of IAMs from the high school period during the second IAM collecting phase than the control participants. This finding clearly suggests that retrieving memories from a particular period of one's personal past, may influence memories that spontaneously come to mind afterwards. We also observed the enhanced tendency to involuntarily retrieve more remote IAMs after reminiscing about the distant past. More specifically, just after reminiscing about the high school, participants experienced more frequently remote IAMs in the high school group compared to the group that did not reminiscence about anything (between-subject differences) and compared to the involuntary IAM collection phase that was not preceded by reminiscing (within-subject differences).

First, our findings support the main conclusions provided by Mace (2005). More specifically, we lend additional empirical evidence to the notion that cognitive activity in general, and the reminiscence-type activity in particular, may change the involuntary retrieval and enhance or attenuate the tendency to experience more or less distant personal past. Therefore, priming may play a role in the IAMs retrieval not only by activating thematically related memories, as it was shown in Study 2 by Mace (2005), but also by activating memories pertaining to a more broad period of time. It appears that this novel priming effect on memories from the remote past demonstrates more indirect effect of priming on involuntary memory retrieval, which is in line with the model proposed by Conway and Pleydell-Pearce (2000). More precisely, as it was observed in the present study, talking about the past (presumably) activated particular levels and nodes in the autobiographical knowledge base, and this activation then spread further throughout the network, increasing the level of activation of more remote memory nodes, which facilitated the future processing of such memory information. As a result, it was more likely for participants in the high school group to retrieve an IAM relating to more distant than recent past compared to control participants. As IAMs usually pertain to most recent past (e.g., Berntsen, 1996; Berntsen & Hall, 2004; Vannucci et al., 2014), it can be argued that it is because they are retrieved from the parts of autobiographical knowledge that were most activated at the moment of retrieval. However, as it was demonstrated in our study, the level of activation may be modified, and therefore, the tendency to retrieve IAMs relating to recent past (e.g., college time for undergraduate students) may be reversed.

It is reasonable to ask to what extent the level of activation remains relatively constant over time. For example, this finding also lends some partial support to the idea that IAMs may be influenced and primed by, for example, preoccupations over one's long-term life situation (Berntsen, 2007). According to Berntsen (2007; see also Mace, 2007) the retrieval of IAMs in everyday life may be influenced by long-term dispositions, such as motivational factors. For instance, an orientation towards individual's goals and expectations may chronically prime a certain subclass of autobiographical memories, which, as a result, are much easier to be elicited involuntarily by incidental cues. While this idea has not yet been addressed, it is clearly an interesting avenue for further research.

As in previous studies (e.g., Mace, 2005; Schlagman & Kvavilashvili, 2008; Vannucci et al., 2014), most memories retrieved by participants in both groups were elicited by external rather than internal cues. For this reason, it is reasonable to ask to what extent the priming effects and cues interact with each other. As mentioned in the introduction, since the triggers usually do not match only to one event, priming may enhance a cue-item discriminability. However, whether the memory will be retrieved or not still depends on the strength of the cue-memory association that may modify the efficacy of priming processes. For example, when the high school and control groups are compared, we would expect to observe more memories from the primed period in response to phrases strongly relating to this period (e.g., *biology test*, *research school project*) in the former group. In addition, one would expect that primed memories, in general, and memories elicited by the period-specific cues, in particular, would be faster elicited. However, in our study we did not observe the differences between groups and phases in terms of the speed of IAMs retrieval (although the main effect of the phase was close to the statistical significance, $p = .071$, with memories slightly slower retrieved during phase 1 compared to phase 2). Yet, the RT for the IAMs (below 2.5 s in the first phases and between 3.27 and 3.43 s in the second phases) correspond very closely to the latencies reported in earlier studies that used different experimental procedures and paradigms (Berntsen et al., 2013; Schlagman & Kvavilashvili, 2008; Staugaard & Berntsen, 2014), which additionally supports the validity and reliability of our experimental design. It is worth to underline that in our study we did not manipulate the type of triggers used (e.g., the extent to which they relate exclusively to the high school time). Thus, word phrases were not strongly associated with the primed lifetime period. However, such association might speed up the retrieval of IAMs. Clearly, the possible interplay between priming and triggers in the retrieval of IAMs is an interesting avenue for future research.

Second, as Mace (2005) suggested, since priming mechanism may be one of at least few controlling factors for the flow and selection of IAMs, by narrowing or broadening the pool of pre-activated memories, we may increase or decrease the likelihood of retrieving either thematically or temporally relating memories. This may have important implications for developing our understating of intrusive memories that are typical for post-traumatic stress disorder

(American Psychiatric Association, 2013; see Mace, 2005 for a similar argument). For instance, intrusive memories may continuously prime all type of mental contents resulting in recurrent experiencing of trauma memories in the sufferers of post-traumatic stress disorder. It addition, priming mechanism may also affect the type of retrieved memories. In our study, it was unexpectedly manifested in the second phase by the lower specificity ratio in the high school group compared to the control group and the difference in the specificity ratio between the first and second phase in the high school group. As it can be seen in Table 2, after priming participants retrieved less specific memories compared to the phase before priming. Put differently, participants were more prone to retrieve memories of general events from the past (e.g., going out with school friends) after reminiscing about the past than before the voluntary remembering session. It is possible that voluntary reminiscing caused pre-activation of higher levels of memory information to more extent compared to lower levels. Therefore, more general memories were easier to retrieve in response to a cue. Although this novel finding requires further investigation, it already suggests that priming may, at least on some occasions, enhance the retrieval of more general memories than it might be expected.

Possible limitations and alternative explanations

When discussing the present results some limitations of our design should be considered. First, it may be argued that participants might be more willing to report having a memory relating to the retrieved period because, for example, they might think that the experimenter is especially interested in such memories. To avoid this risk, we assured all participants that these two parts had nothing in common and should not be treated as interrelated. In addition, all participants answered open-ended questions concerning what they thought was the true goal of the study. As reported in the results section, none of the participants reported having guessed the true relation between the voluntary memory recording phase and the IAM colleting phase. Importantly, had they guessed the true relation, we would have expected to observe more memories in the high school group compared to the control group in the second phase. Yet, the lack of group differences in this regard speaks against such an alternative explanation. Participants were not more inclined to record involuntary thoughts or memories after the voluntary memory recording phase compared to the control group. Importantly, by instructing them to write down any type of mental content we also avoided placing the focus of attention on retrieval of IAMs.

Second, it may be argued that participants were likely to engage in the voluntary retrieval of autobiographical memories during the IAM colleting phase. However, in order to minimise plausible voluntary retrieval during the IAM collecting phase, participants were instructed to report any spontaneously occurring thoughts without putting any emphasis on memories (see also Barzykowski et al., 2016; Barzykowski & Staugaard, 2016; Vannucci et al., 2014, for the same procedure). As it was shown in a recent study by Barzykowski et al. (2016), this procedure is effective in minimising the frequency of voluntary memories retrieved during the IAM collecting phase.

Third, elaborating further on the possibility that IAMs were the product of an intentional retrieval, Mace (2005) inspected the pattern of cues triggering IAMs. He argued that the low level of internal cues and the high level of external triggers made it less likely that participants voluntarily tried to retrieve memories. If it was the case, we would expect to observe more memories triggered by thoughts compared to external cues words presented in the vigilance task. Yet, similar to previous studies (e.g., Mace, 2005; Schlagman & Kvavilashvili, 2008; Vannucci et al., 2014) most cues identified by participants in our study were external words. Finally, the examination of retrieval times of IAMs provides further support for the idea that memories were recalled involuntarily. In particular, in previous studies voluntary memories were retrieved at fastest in 6108 s (Berntsen et al., 2013, Study 2; see also Barzykowski & Staugaard, 2016; Schlagman & Kvavilashvili, 2008), while retrieval times observed in our study ranged from 2.43 to 3.43 s. We therefore argue that given somewhat low percentage of memories with internal thought-based triggers (range between 10% and 21% compared to 19% reported by Mace in Study 2), high percentage of external (word-based) triggers (range between 69% and 86%), low retrieval times, as well as the responses to post-task survey, it is rather unlikely that the results were affected by intentional retrieval.

Fourth, one may argue that using verbal cues might in general attenuate the priming effect, especially because they were not highly personalised as they usually are in everyday life. In addition, since participants were provided with the same sets of cues twice, the priming effect might be especially suppressed. For these reasons, future studies should ideally use different sets of cues that will be at the same time idiosyncratic and individually tailored to each participant. Fifth, as was suggested by Mace (2005), involuntary retrieval may occur minutes, hours or even days after priming. As we studied participants' cognitive activity during relatively short period of time, we may expect to observe more primed memories outside the laboratory after the experiment. This would be in accordance with Mace's findings (2005) showing that most of primed memories were collected a day or a few days after voluntary memory recording session. For this reason, future studies may be extended by a diary phase that would follow the laboratory session. It should be stressed, however, that despite potential shortcomings of our procedure that were discussed above, we did demonstrate the priming effect on IAMs and these shortcomings only suggest that the priming effect may be stronger than the one we found.

Finally, it can be argued that providing participants with the same set of verbal phrases during the second IAM colleting phase might have caused the interference between IAMs retrieved during the first phase and newly primed IAMs during the second phase. Such competition might have reduced the effect of priming, especially since a list of cues was relatively short. This may be the reason for relatively low amount of IAMs observed in the second IAM phase and for the within-subject priming effect that only approached statistical significance. Future studies should control for this possible limitations, by providing participants with longer, and even more importantly, different sets of cues during the first and second IAM phase. This may boost the effect of priming on IAMs.

Final conclusions

While we used a shorter and weaker manipulation of priming than was used by Mace (2005) (i.e., 12–15 min vs. 30 min of voluntary recall), we were still able to observe a significant priming effect in the involuntary memory retrieval. Our findings demonstrate that retrieving voluntary memories from the past may facilitate the activation of IAMs related to the same period of time. In addition, remembering personal past may enhance the tendency to experience more remote IAMs. Our study supports the idea that IAMs may rely, to some extent, on the priming effect and spreading activation mechanism. The findings suggest that IAMs can be considered as a product of organised cognitive processes rather than random and chaotic cognitive activity.

Notes

1. Please note that throughout the paper these phases are also called the first or the second involuntary memory (IAM) collecting phase.
2. Throughout the paper this phase is also called the voluntary memory recording phase.
3. Please note that since most participants in the present study were undergraduate students, the college time and after college time relate either to their present or most recent past, while periods before the high school time relate rather to the remote past.
4. The Polish adaptation of verbal phrases is described in detail elsewhere (Barzykowski et al., 2016, p. 6).
5. Please note that we used the same set of cues during the first and second phase to be sure that the possible differences between the first and second phase were due to the manipulation used rather than to the differences between cues.
6. It measures the strength of negative and positive emotions and consists of 30 items measuring current emotional states. Participants have to rate on a 5-point scale to what extent the given adjectives correspond with their current state. The reliability coefficients (internal consistency and stability) for the questionnaire equalled .73–.95. It was applied in order to control for comparability of studied groups. For example, it is possible that voluntarily reminiscing about high school period may somehow affect participants' mood.
7. Please note that by employing two practise sessions we were able to sequentially provide participants with crucial elements of the procedure (i.e., vigilance task instruction and involuntary thought recording instruction) followed by a relevant practise session.
8. The voluntary memory recording module in the high school group took, on average, 12.94 minutes (SD = 4.22).
9. Please note that participants knew that they would do the vigilance task twice and, therefore, the repetition of cue-words was something understandable and expected to them. To our best knowledge, participants did not pay any special attention to the repetition of verbal cues and they were not surprised by its occurrence.
10. Please note that in order to examine the effects of priming it was necessitated to include into the mixed ANOVAs reported below only participants that had at least one memory reported in both phase 1 and 2. Therefore the total number of valid participants was 35 (17 in the control group and 18 in the high school condition).

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